SCIENTIFIC ARTICLE

Effect of Facility on the Operative Costs of Distal Radius Fractures

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Purpose The purpose of this study was to investigate whether ambulatory surgery centers can deliver lower-cost care and to identify sources of those cost savings.

Methods We performed a cost identification analysis of outpatient volar plating for closed distal radius fractures at a single academic medical center. Multiple costs and time measures were taken from an internal database of 130 consecutive patients and were compared by venue of treatment, either an inpatient facility or an ambulatory, stand-alone surgery facility. The relationships between total cost and operative time and multiple variables, including fracture severity, patient age, gender, comorbidities, use of bone graft, concurrent carpal tunnel release, and surgeon experience, were examined, using multivariate analysis and regression modeling to identify other cost drivers or explanatory variables.

Results The mean operative cost was considerably greater at the inpatient facility ($7,640) than at the outpatient facility ($5,220). Cost drivers of this difference were anesthesia services, post-anesthesia care unit, and operating room costs. Total surgical time, nursing time, set-up, and operative times were 33%, 109%, 105%, and 35% longer, respectively, at the inpatient facility. There was no significant difference between facilities for the additional variables, and none of those variables independently affected cost or operative time.

Conclusions The only predictor of cost and time was facility type. This study supports the use of ambulatory stand-alone surgical facilities to achieve efficient resource utilization in the operative treatment of distal radius fractures. We also identified several specific costs and time measurements that differed between facilities, which can serve as potential targets for tertiary facilities to improve utilization. *(J Hand Surg 2011;xx:. Copyright © 2011 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Economic and Decisional Analysis III.

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As the cost of providing health care continues to rise, strategies to contain those costs have become increasingly important. Ambulatory, stand-alone surgery centers (ASCs) and similar entities (specialty hospitals) have several proposed benefits—most importantly, the ability to provide high-quality care at a lower cost.[1–6] Previous studies in other specialties have supported these theories.[3,7–10] One study evaluated anterior cruciate reconstruction and observed fewer operative charges for procedures performed at an ASC, but actual costs have not been examined.[11] Other studies have used the cost-to-charge ratio to approximate the actual resources used to deliver surgical treatment.[9,12–14] Still other studies have not supported the proposed benefits of ambulatory surgery.[15,16] In addition, the specific factors contributing to the operating efficiencies of ASCs are unknown.

At our institution, outpatient operative treatment of distal radius fractures is performed at both the inpatient hospital and the ASC; therefore, this model of cases was chosen to compare the operating efficiency of the 2 facilities. The particular strengths of this model are the identical surgeons, implant cost, and patient characteristics that allow the effect of facility to be isolated. In this study, we performed a retrospective analysis of the operating efficiency for a common surgical procedure performed at a major academic medical center's inpatient hospital and hospital-owned ASC. The purpose of this study was to investigate whether ASCs provide lower cost care than inpatient facilities and, using detailed cost and time stamp data, to find the source of any differences.

MATERIALS AND METHODS

Study design

We used a retrospective cost-identification study design to evaluate the effect of facility type on the operative costs and time for 130 closed distal radius fractures for which patients were treated as outpatients with a volar plate at a large academic medical center by 8 fellowship-trained hand surgeons. Of these 130 patients, 93 were treated at the ASC and 37 at the inpatient hospital. Unequal numbers occurred for 2 reasons. The hand and upper extremity surgeons have more block time as a percentage of their total available operative time at the ASC, which facilitates its use. Second, we excluded all inpatient cases to increase the homogeneity of the study groups. This eliminated many cases performed at the inpatient facility for reasons including unstable comorbid medical conditions and polytrauma. Institutional review board approval was obtained for this study.

Data source

Actual hospital cost and time stamp data were taken from the institutions' decision support repository database (Healthcare Transaction Base, Oracle Corp., Redwood Shores, CA). The database was created in 2005, and patients were reviewed from 2005–2008. Inclusion criteria were outpatient treatment and common procedural terminology codes 25607 (open treatment of distal radial extra-articular fracture or epiphyseal separation with internal fixation), 25608 (open treatment of distal radial intra-articular fracture or epiphyseal separation with internal fixation), 25609 (open treatment of distal radial intra-articular fracture with internal fixation of 3 or more fragments), and 25620 (open treatment of a distal radial fracture (eg, Colles or Smith type) or epiphyseal separation with or without fracture of ulnar styloid, with or without internal or external fixation).

Demographic and procedure-specific data were taken from the electronic medical record. Exclusion criteria were pediatric cases (age less than 18), treatment for malunion/nonunion, inpatient cases, open fractures, use of any implants other than a volar plate, and cases with any additional procedural codes other than those listed earlier, except carpal tunnel release.

Variables

Outcomes. Outcome variables consisted of cost and time. Total cost was defined as the cost to the providing institution for the materials and labor needed to perform the operative procedure only. Total cost was analyzed by subgroup, including 5 specific cost buckets: anesthesia services (no professional fees were included), operative (fixed and variable operating room fees), hardware (implanted items), pharmacy, and post-anesthesia care unit (PACU). No costs incurred beyond discharge from the PACU were included. The final subgroup was surgical service costs; the difference between surgical service and total cost includes several components including laboratory and radiology services. The term *cost bucket* refers to the organization of individual costs into groups for ease of analysis. Documentation of the time an event occurs, whether it is the beginning of anesthesia, the time a patient enters the operating room, or the time a dressing is applied, is referred to as a *time stamp*. Time stamps included total time, start time (anesthesia record start to incision), set-up time (nurse in room to incision), operative time (incision to final closure of wound including dressing), and nursing time (time the nurse entered the room to incision plus time from the closure of the incision to patient exit from the room). A direct measure of turnover time was not available; although not ideal, nursing time was used as the best surrogate.

Main predictors. The primary predicting variable was facility type. This was a binary variable, and 2 types of facilities were examined. One is the main operating room at the inpatient hospital of a major academic medical center. The second is a hospital-owned ASC on the campus of the academic medical center. It is a multi-specialty facility, and only elective cases are performed there. Infirm patients are not operated on at the ASC under any circumstances, and patient selection policies are in place to support safety and efficiency. To examine similar patients and cases, many cases at the inpatient facility were excluded so that a relatively healthy, low-risk sample was examined. Each surgeon in the series operated at both facilities. The decision regarding at which location a procedure was to be performed was based on what block time was available with no prerequisite differences in allowable age, comorbidities, or insurance status. The physicians, nurses, and support staff at our institution have no financial relationships or profit-sharing agreements with either facility. If profits remain at the end of the fiscal year, they are returned in whole to the hospital. Because the parent medical center owns the ASC, it is not reimbursed by capitation as physician-owned ASCs are. Therefore, no incentive structure exists to use less-expensive implants or other supplies. These characteristics remove potential explanatory variables and allow focused assessment of the operating efficiency of each facility.

Explanatory variables. Explanatory variables included age, gender, fracture severity, surgeon experience, use of bone graft, concurrent carpal tunnel release, comorbidities, and time from injury to surgery. Fracture severity was measured using the AO classification for distal radius fractures. Preoperative radiographs were classified by 2 of the authors independently. Surgeon experience was calculated using the difference in months between the date of training completion for the attending surgeon and the date of surgery. Comorbidities were measured using the American Society of Anesthesiologists Physical Status Classification score.[17,18]

TABLE 1. Confounding Variables at the Inpatient and Ambulatory Surgery Center

	Ambulatory	Inpatient	p Value
Age	48	51	.285
Gender			
Male	36%	38%	.801
Female	65%	62%	
ASA classification*			
I	47%	54%	.541
II	31%	35%	
III	20%	11%	
Fracture severity†			
23A	31%	30%	.922
23B	8%	8%	
23C	60%	60%	
Bone graft	12%	5%	.271
Carpal tunnel release	10%	22%	.068
Surgeon experience (y since fellowship)	14	9	.251
Surgical delay (d)	7	5	.06

*The American Society of Anesthesiologists physical status classification system is a system for assessing the fitness of patients before surgery[18]: I, normal, healthy patient; II, a patient with mild systemic disease; III, a patient with severe systemic disease.

†Fracture severity was determined using the AO classification: 23A, extra-articular fractures; 23B, simple articular fractures; 23C, complex articular fractures.

Statistical methods

Descriptive statistics were calculated for all outcome, predictor, and explanatory variables. Categorical variables were reported with frequency and percentages. A cross tabulation with Pearson chi-square test was used to test association between 2 categorical variables. If frequency in at least 1 cell of cross tabulation would be less than 5, the Fisher's exact test was used instead of the Pearson chi-square test. Two-sample, independent sample t-test was used to compare the mean difference between 2 groups. One-way analysis of variance was used to compare mean differences between more than 2 groups. Multiple linear regression analysis was performed for total cost and total time with predictor variables and explanatory variables as explanatory variables to identify their risk-adjusted association with outcome variables. In these models, selection of potential confounders followed the criteria established by Greenland and Pearl,[19] thus ensuring that explanatory variables were associated with both outcome and predictor variables. Because time and cost variables did not present a normal distribution, a log-transformation was performed. Models using transformed and untransformed variables led to similar results; therefore, only the former are presented. All tests were calculated with a 95% confidence interval.

We performed a post hoc power analysis. We calculated the power for the main comparison in this study to estimate the total cost difference between the inpatient and outpatient settings. Conservatively assuming values of a difference of $2,400 between these categories, a standard deviation of $800, significance level of .05, and total sample of 130 subjects, the study power is estimated to be 0.99.

Source of funding

There was no external funding source for this study.

RESULTS

There was no significant difference ($P<.05$) between the inpatient and ambulatory facilities for any explanatory variable (Table 1). Linear regression analysis revealed that the only variable independently affecting total cost or total time was

TABLE 2. Results of the Linear Regression Analysis for Both Total Cost and Total Time for Each Variable

Variable	Beta Coefficient*	95% CI	p Value
Total cost			
ASA status	318	(−74–709)	.111
Bone graft	−45	(−973–882)	.923
Carpal tunnel release	87	(−704–879)	.827
Gender	−497	(−1086–92)	.097
Age	−0.96	(−21–19)	.925
Surgeon experience	4	(−11–19)	.600
Facility	2,476	(1872–3078)	<.001
Fracture severity (AO classification)	87	(−205–379)	.556
Total time			
ASA status	1251	(−106–2608)	.070
Bone graft	1088	(−2030–4206)	.491
Carpal tunnel release	1648	(−1089–4385)	.235
Gender	−1354	(−3370–661)	.186
Age	−35	(−103–32)	.300
Surgeon experience	−20	(−70–30)	.432
Facility	5732	(3690–7776)	<.001
Fracture severity (AO classification)	487	(−505–1480)	.333

*The beta coefficient is the correlation between the independent variable and the outcome variable. The great value of the beta-coefficient is that it expresses the "effect" of one variable on another without regard to how differently the variables are scaled.

facility type. Fracture severity had no significant effect on total cost or time. The results of this regression analysis can be found in Table 2. Furthermore, the variable cost per minute of operative time did not differ between facilities.

The effect of facility on total cost and time was significant. Mean total cost was $5,220 at the ASC versus $7,640 at the inpatient hospital. Therefore, total cost at the ASC was $2,420 (46%) less than at the inpatient facility ($P<.001$). Analysis of the specific cost buckets revealed statistically significant differences between facilities for all but implants. Anesthesia costs were $784 at the ASC versus $909 at the inpatient facility, a $125 or 16% difference. Operating room costs were $1,827 at the ASC versus $2,992 at the inpatient facility, a difference of $1,165 or 64%. Pharmacy costs were $320 at the ASC versus $458 at the inpatient facility, a $138 or 43% difference. Finally PACU costs were $365 at the ASC versus $660 at the inpatient facility, a $295 or 81% difference. Hardware costs were nearly identical between facilities. These results are shown in Table 3.

Mean total time at the ASC was 94 minutes (33%) less for the same procedure than at the inpatient facility. Specific time stamps showed significantly shorter operative time, 45 minutes (35%); set-up time, 22 minutes (105%); and nursing time, 48 minutes (120%) at the ASC, which drove this finding. Start time, however, was 18 minutes (38%) longer at the ASC. These results are shown in more detail in Table 4.

DISCUSSION

We found marked differences for both cost and time between the 2 facilities. The ASC was less costly and quicker at delivering the same surgical procedure when compared to the inpatient facility. Furthermore, regression analysis revealed facility type to be the only significant predictor of operative cost and time when treating a distal radius fracture with a volar plate.

Drivers of that cost difference were stratified throughout the delivery of the service. Although the greatest difference was seen in the operative cost bucket, significantly higher anesthesia and PACU costs were also observed. Analysis of the time stamps showed set-up and nursing times to be more than 100% longer at the inpatient facility. Because the hardware costs at each facility were equal and the same devices are available at each facility, we removed the hardware cost to better assess the actual operating efficiency difference. The total cost was $3,279 at the ASC and $5,713 at the inpatient facility. The actual cost difference between the facilities in this scenario changed little, increasing from $2,420 to $2,434. However, the percentage difference was dramatic, 73% lower in this scenario compared to 46% lower in the overall measure.

This study targets areas to enhance resource utilization. At our institution, surgeons have assigned operative time at both the inpatient and outpatient facilities. However, this study suggests that adequate access to the ASC should be given to each surgeon to improve efficiency, which we define in this study as the extent to which time and money are used to complete the intended task. Specialized orthopedic teams are used at both facilities, with only 3 cases outside the typical workday being included from the inpatient facility. Of

TABLE 3. Cost Bucket Analysis at the Inpatient and Ambulatory Surgery Center

Cost Bucket	Facility	Mean	95% CI	p Value
Anesthesia*	Ambulatory	$784	($736–$831)	.006
	Inpatient	$909	($709–$858)	
Hardware	Ambulatory	$1,941	($1,836–$2,046)	.889
	Inpatient	$1,927	($1,777–$2,078)	
Operating room	Ambulatory	$1,827	($1,775–$1,879)	<.001
	Inpatient	$2,992	($2,655–$3,329)	
PACU	Ambulatory	$365	($345–$385)	.032
	Inpatient	$660	($238–$1,081)	
Pharmacy	Ambulatory	$320	($266–$374)	.007
	Inpatient	$458	($379–$537)	
Surgical service†	Ambulatory	$4,890	($4,729–$5,052)	<.001
	Inpatient	$6,546	($5,935–$7,157)	
Total	Ambulatory	$5,220	($5,040–$5,400)	<.001
	Inpatient	$7,640	(6,862–$8,418)	

*Excludes professional fees and includes supplies, time, and medication.
†Surgical service costs are a total of anesthesia, hardware, operating room, and PACU. The buckets excluded from this total include pharmacy, radiology, and other small contributing buckets.

TABLE 4. Time Stamp Analysis at the Inpatient and Ambulatory Surgery Center

Time (min)*	Ambulatory (95% CI)	Inpatient (95% CI)	p Value
Total time	290 (277–303)	384 (345–423)	<.001
Start time	66 (57–75)	48 (36–60)	.033
Set-up time	21 (17–25)	43 (34–52)	<.001
Operative time	129 (122–136)	174 (155–193)	<.001
Nursing time	40 (23–57)	88 (57–119)	<.001

*Time stamps included total time, start time (anesthesia record start to incision), set-up time (nurse in room to incision), operative time (incision to final closure of wound including dressing), and nursing time (time the nurse entered the room to incision plus time from the close of the incision to patient exit from the room). A direct measure of turnover time was not available; although not ideal, nursing time was used as the best surrogate.

these, 2 were higher than average and 1 was well below average for cost and time. Further study of these 2 facilities is necessary to elicit the root cause for the difference, but we can identify areas in which this further study should be focused.

Other authors have examined the effect of facility. Karkarlapudi et al studied 100 patients with distal radius fractures from presentation to discharge and found that inpatient service costs accounted for the bulk of expenditures. Furthermore, they proposed that the lack of a standardized outpatient treatment protocol led to increased costs.[20] They suggested that further study was necessary to examine the effect of ambulatory care on the treatment of distal radius fractures. Leblanc et al examined the cost and efficiency in the operative treatment of carpal tunnel syndrome and compared the effect of facility. They found the inpatient operating room to be 4 times as expensive and less than half as efficient as the ambulatory surgery facility; however, surveys, instead of actual operative costs or operative times, were the source of the data.[21] Novak et al examined the effect of facility on the cost of anterior cruciate ligament reconstruction.[11,22] The ambulatory facility incurred average charges of $4,960 less than the inpatient facility, although each facility was associated with a different surgeon. This finding was statistically significant. Surgical times and actual costs were not examined.

This study expands on the previous studies performed. The strengths of this study are the standardization of the index procedure, the elimination of the explanatory variables of physician ownership and capitation, the review of actual operative costs, and specific time stamps and cost buckets to identify a source of the variation. Although using the cost–charge ratio to estimate costs can be an effective strategy to estimate the resources used to provide a service, health economists have pointed out its limitations.[23–25] The elimination of physician ownership and capitation can remove potential conflicts of interest and allow focused assessment of the operating efficiencies.

The strength of this study in reporting actual costs and specific times also reveals a weakness. The data come from only 1 institution and might not necessarily be extrapolated to other providers. Along these lines, our findings originate from a tertiary medical center and might not be extrapolated to the community. Although our results are based on data from a tertiary facility, it is plausible that community practices would have patterns that share several of the characteristics described in our study. For example, community physicians often cover several hospitals and might not have control over their operating room block time, as our surgeons did not. In addition, most of the patients in our study were referred from the emergency department, reflecting community injuries, not referrals as many cases at tertiary centers are. Finally, the characteristics of tertiary care centers are shared between the 2 facilities, such as each involving residents and fellows. In other words, they cancel each other out. However, future studies should focus on community facilities.

Furthermore, this study is retrospective. A prospective, multicenter study or a nationwide database study with actual costs and specific times could further elucidate these findings. Another weakness is the disparity in the number of operations at the ASC versus the inpatient hospital. Many distal radius fractures are treated operatively at the inpatient hospital on an inpatient basis. To isolate the effect of facility on cost and time, we felt that limiting the analysis to outpatient cases only outweighed the potential explanatory effects of including inpatients. We did not directly measure trainee involvement in the procedure, but we do know that trainees were involved in every case in this series. In addition, we did not directly investigate attending physicians' patterns of facility assignment of cases. However, in interviewing each attending physician, we found that no financial incentives exist to assign a distal radius fracture to either facility.

Finally, we cannot evaluate the affect of physician or staff ownership of the ambulatory facility or assess the impact of reimbursement structure. Much attention has been focused on the effect on cost and quality of care of this potential conflict of interest. Several studies have found evidence that physician-owned ASCs can decrease access to care for lower socioeconomic classes and disproportionately increase utilization of profitable procedures.[1,3,15,16] However, given the compelling evidence for the efficiency of ASCs and specialty hospitals, attention should be focused on reforming the negative incentives rather than limiting the use of an efficient resource. A study of similar design to this, but isolating the effect of physician ownership and capitation, would provide necessary insight into this problem. Finally, we examined only half of the efficiency equation. That is, we did not examine effectiveness (utility or quality of life) of each facility, only cost. A complete economic analysis should provide a measure of value, or unit of benefit divided by unit of cost. Any economic analysis must include a preference-based measure of general health; in other words, it must represent a patient making choices between 1 health state or another. A more complete study design would include adding a general preference–based measure of health-related quality of life to define the value of ASCs. However, other authors have found increased quality of care at orthopedic specialty hospitals, and others have found no difference in adverse events as ASCs for non-orthopedic procedures.[2–4,6,8,26,27] Although we did not directly assess quality of care outcomes or patient satisfaction, the surgeons felt that there was no difference.

Previous studies have highlighted the impact of provider characteristics exerting a substantial effect on resource utilization.[28,29] This study further supports those findings. Furthermore, demographic and disease-specific variables in this study did not affect cost or time. Rather, a factor much within provider control, facility type, did.

This study has important implications for policy makers, administrators, and clinicians. With physicians responsible for the majority of health care expenditures, our understanding of cost drivers and efficient resource utilization is vital to controlling cost growth. Policy makers and administrators should recognize the important role of ASCs and work to maximize utilization of this efficient resource. Rather than throw the good out with the bad, balancing conflicts of interest while encouraging increased operating efficiencies is necessary. Furthermore, the findings that provider rather than patient characteristics affected cost reinforces the opportunity that providers have to influence cost containment.

The use of ASCs and specialty hospitals in the delivery of cost-effective health care has been hotly debated, and several authors have written about their advantages.[30–32] As we are directly in the midst of tumultuous times for health care policy, delineating health care delivery strategies that provide less costly care is critical. This study expands on the findings of others and provides empirical evidence for increased utilization of ASCs.

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